Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

# Estimation of COVID-19 Impact in Virginia

June 1st, 2022

(data current to May 28th – June 1st)

Biocomplexity Institute Technical report: BI-2022-1535

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biocomplexity.virginia.edu

# About Us

- Biocomplexity Institute at the University of Virginia
  - Using big data and simulations to understand massively interactive systems and solve societal problems
- Over 20 years of crafting and analyzing infectious disease models
  - Pandemic response for Influenza, Ebola, Zika, and others


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# Overview

- **Goal**:  Understand impact of COVID-19 mitigations in Virginia
- **Approach:**
  - Calibrate explanatory mechanistic model to observed cases
  - Project based on scenarios for next 4 months
  - Consider a range of possible mitigation effects in "what-if" scenarios
- **Outcomes:**
  - Ill, Confirmed, Hospitalized, ICU, Ventilated, Death
  - Geographic spread over time, case counts, healthcare burdens

# Key Takeaways

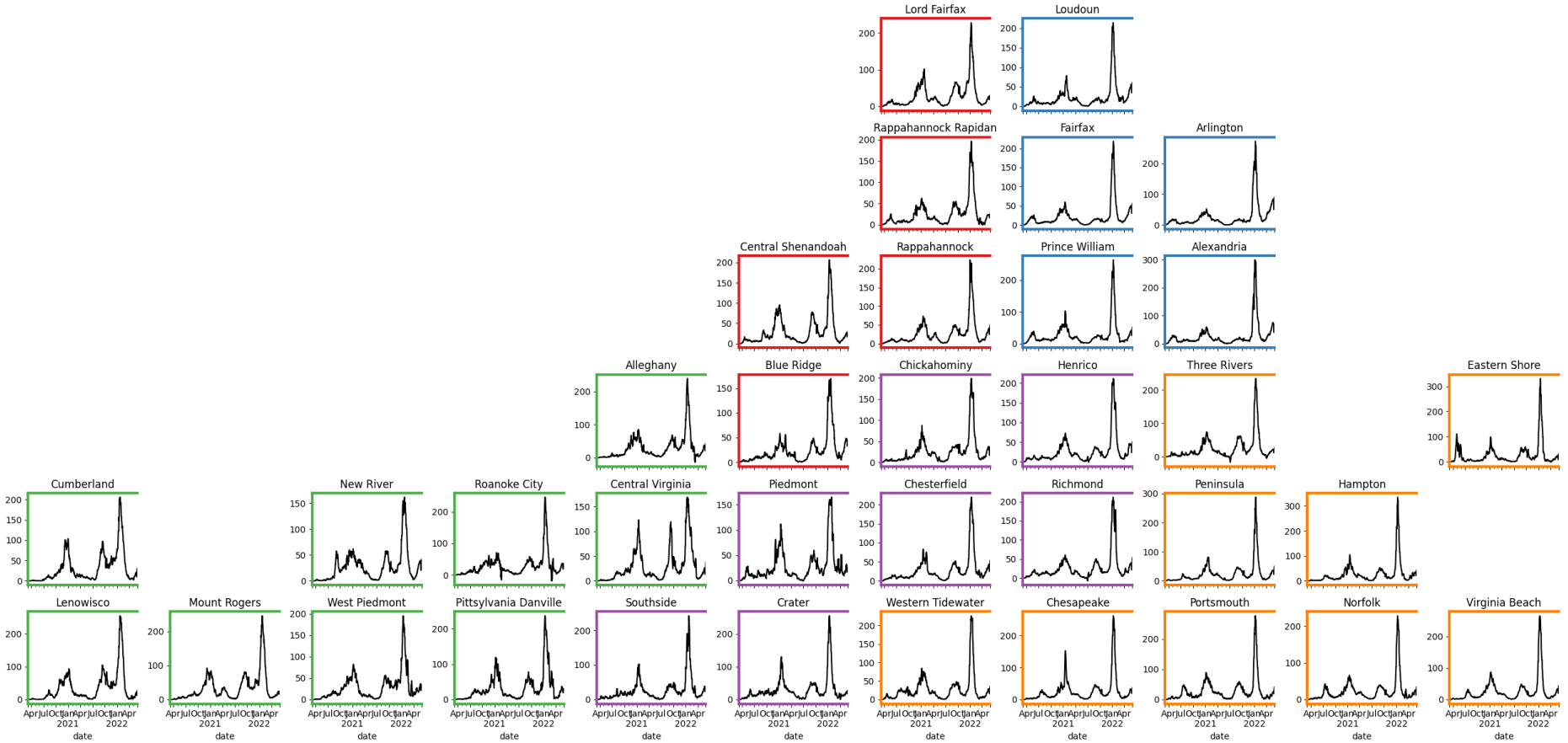
Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

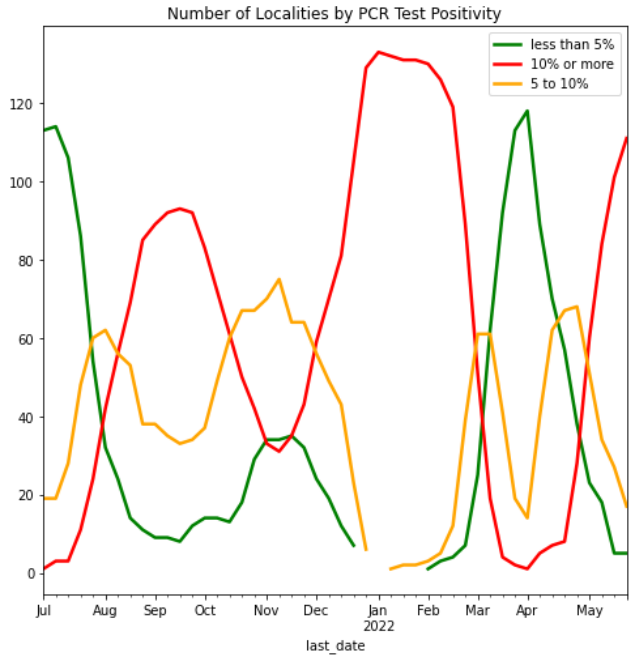
- **Case rates and hospitalizations seem to have peaked and started to decline**
- VA 7-day mean daily case rate slightly down to 37/100K from 39/100K
  - US continues to decline to 36/100K (from 33/100K)
  - VA hospital occupancy (rolling 7 day mean of 550) continues steady rise
- Holiday effect clouds recent surveillance, however, trends from other states suggest a slowing is possible around the moderately high levels currently experienced in VA
- BA.2.12.1 continues to rise, but pace of growth has stalled
- Age

The situation continues to change. Models continue to be updated regularly.

# Situation Assessment

# Case Rates (per 100k) and Test Positivity




**County level RT-PCR test positivity**

Green: <5.0% (or <20 tests in past 14 days)

Orange: 5.0%-10.0% (or <500 tests and <2000 tests/100k and >10% positivity over 14 days)

Red: >10.0% (and not "Green" or "Yellow")

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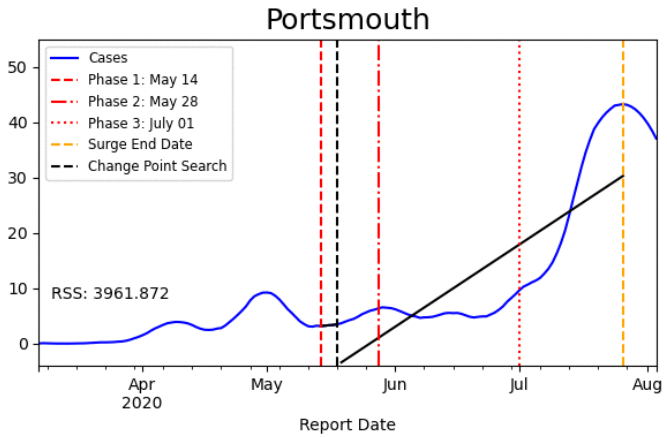
# District Trajectories

**Goal:** Define epochs of a Health District's COVID-19 incidence to characterize the current trajectory

**Method:** Find recent peak and use hockey stick fit to find inflection point afterwards, then use this period's slope to define the trajectory

Hockey stick fit

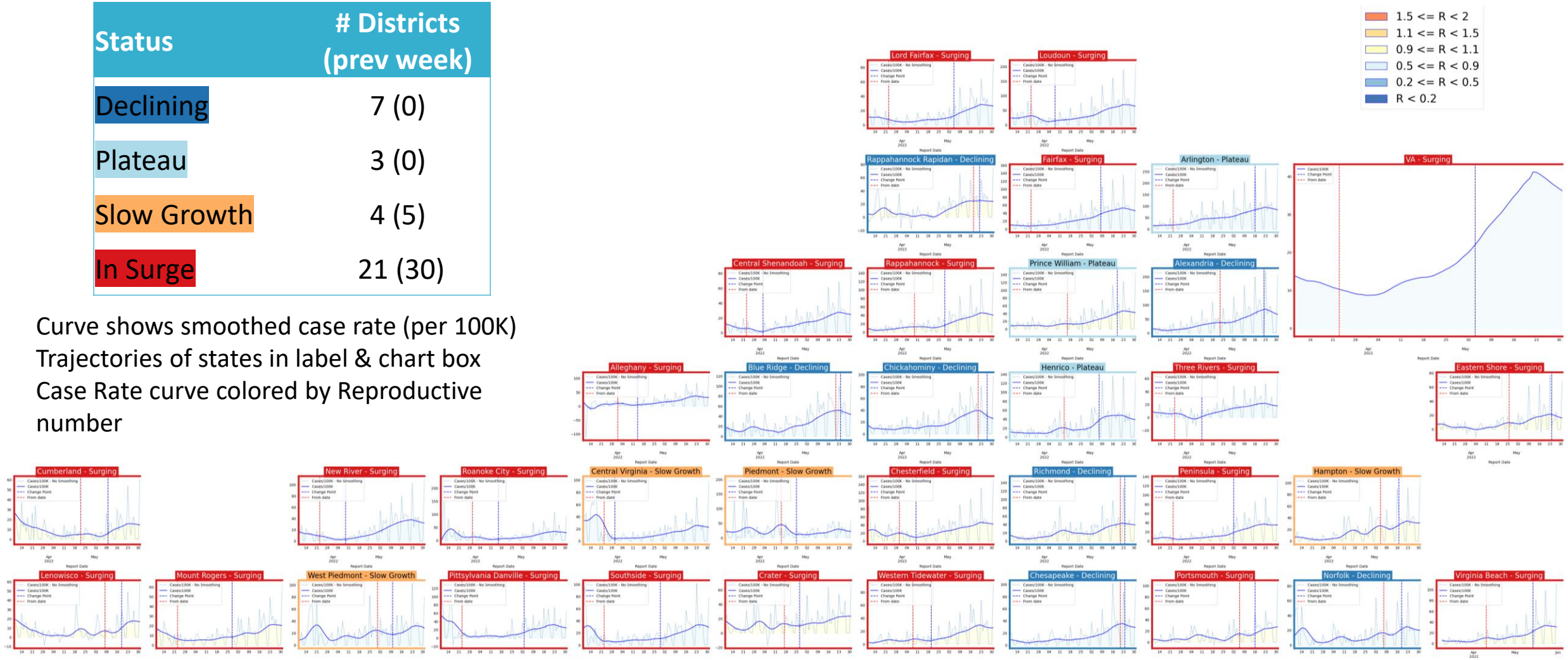



| Trajectory | Description | Weekly Case Rate (per 100K) bounds |
|---|---|---|
| **Declining** | Sustained decreases following a recent peak | below -0.9 |
| **Plateau** | Steady level with minimal trend up or down | above -0.9 and below 0.5 |
| **Slow Growth** | Sustained growth not rapid enough to be considered a Surge | above 0.5 and below 2.5 |
| **In Surge** | Currently experiencing sustained rapid and significant growth | 2.5 or greater |

# District Trajectories – last 10 weeks

| Status | # Districts (prev week) |
|---|---|
| Declining | 7 (0) |
| Plateau | 3 (0) |
| Slow Growth | 4 (5) |
| In Surge | 21 (30) |

Curve shows smoothed case rate (per 100K)
Trajectories of states in label & chart box
Case Rate curve colored by Reproductive number



# CDC's new COVID-19 Community Levels

## What Prevention Steps Should You Take Based on Your COVID-19 Community Level?

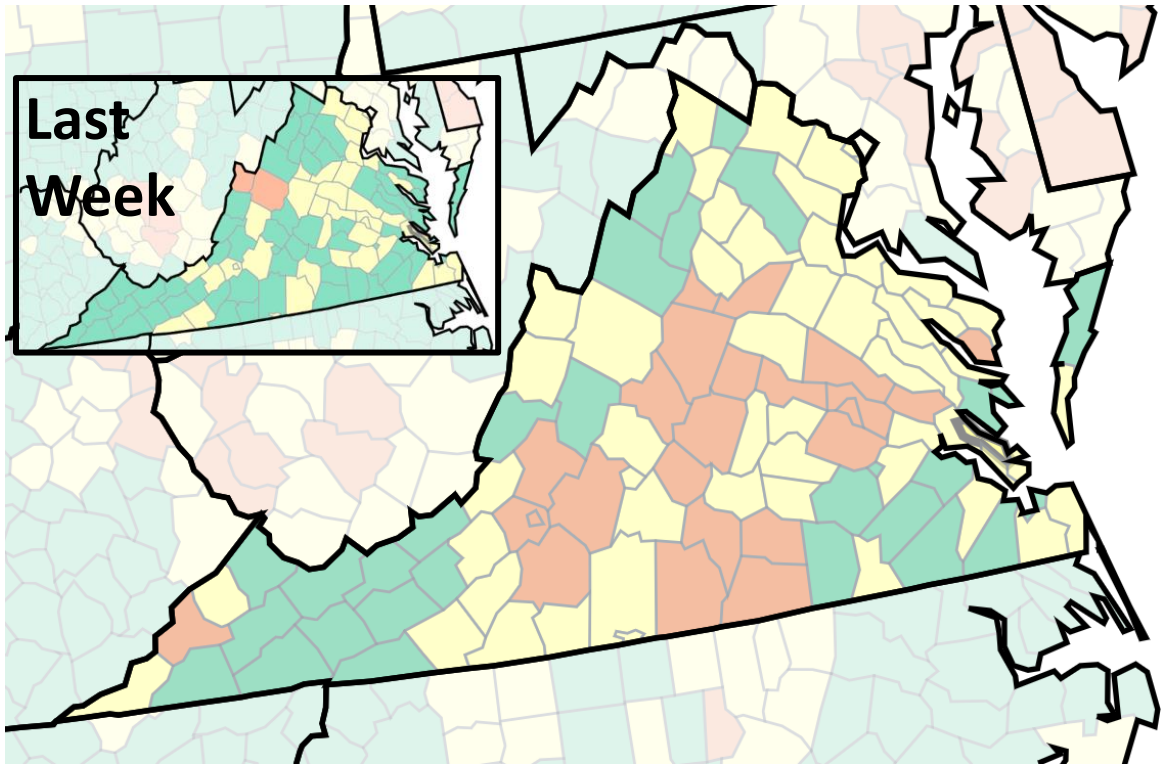
| Low | Medium | High |
|---|---|---|
| • Stay up to date with COVID-19 vaccines<br>• Get tested if you have symptoms | • If you are at high risk for severe illness, talk to your healthcare provider about whether you need to wear a mask and take other precautions<br>• Stay up to date with COVID-19 vaccines<br>• Get tested if you have symptoms | • Wear a mask indoors in public<br>• Stay up to date with COVID-19 vaccines<br>• Get tested if you have symptoms<br>• Additional precautions may be needed for people at high risk for severe illness |

People may choose to mask at any time. People with symptoms, a positive test, or exposure to someone with COVID-19 should wear a mask.

COVID-19 Community Levels – Use the Highest Level that Applies to Your Community

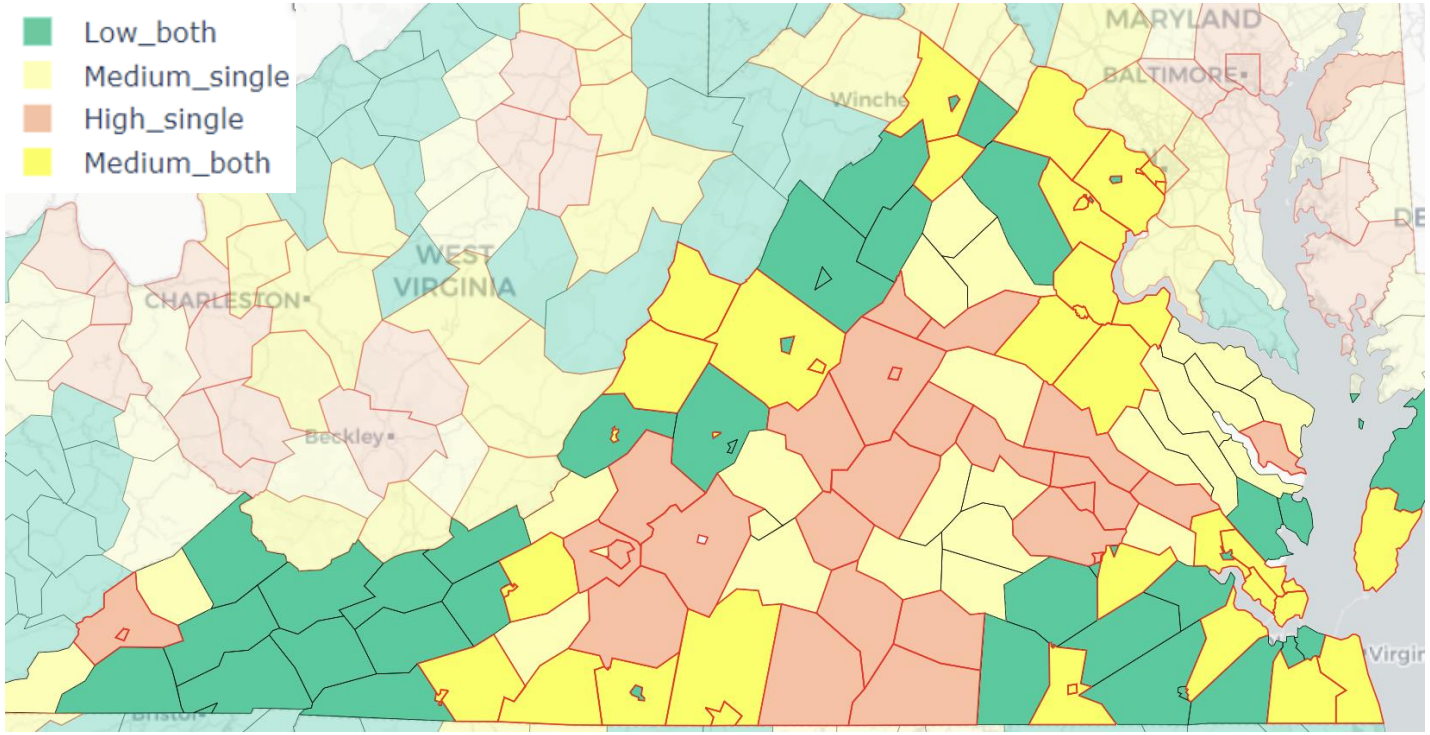
| New COVID-19 Cases Per 100,000 people in the past 7 days | Indicators | Low | Medium | High |
|---|---|---|---|---|
| Fewer than 200 | New COVID-19 admissions per 100,000 population (7-day total) | <10.0 | 10.0-19.9 | ≥20.0 |
| | Percent of staffed inpatient beds occupied by COVID-19 patients (7-day average) | <10.0% | 10.0-14.9% | ≥15.0% |
| 200 or more | New COVID-19 admissions per 100,000 population (7-day total) | NA | <10.0 | ≥10.0 |
| | Percent of staffed inpatient beds occupied by COVID-19 patients (7-day average) | NA | <10.0% | ≥10.0% |

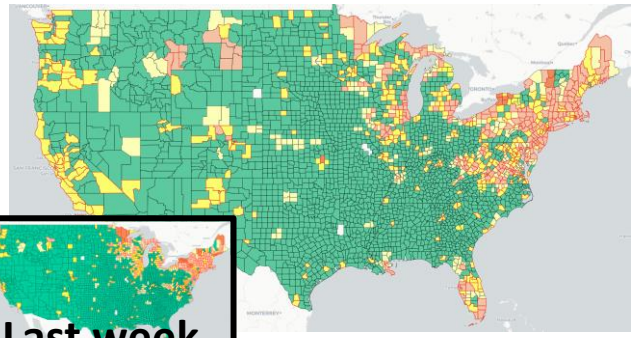
The COVID-19 community level is determined by the higher of the new admissions and inpatient beds metrics, based on the current level of new cases per 100,000 population in the past 7 days

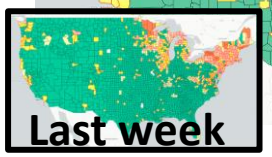


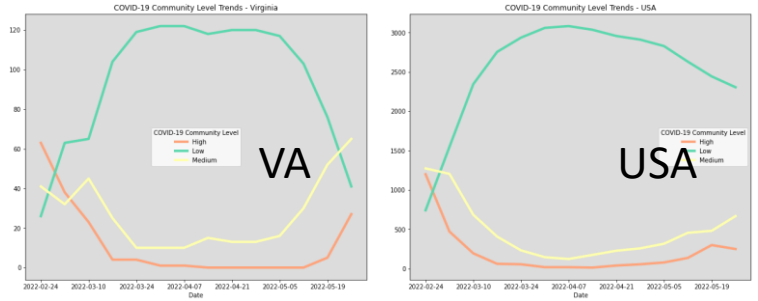

[CDC Data Tracker Portal]

# CDC's new COVID-19 Community Levels






**Red outline indicates county had 200 or more cases per 100k in last week**

**Pale color indicates either beds or occupancy set the level for this county**

**Dark color indicates both beds and occupancy set the level for this county**

COVID-19 Community Levels – Use the Highest Level that Applies to Your Community

| New COVID-19 Cases Per 100,000 people in the past 7 days | Indicators | Low | Medium | High |
|---|---|---|---|---|
| Fewer than 200 | New COVID-19 admissions per 100,000 population (7-day total) | <10.0 | 10.0-19.9 | ≥20.0 |
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The COVID-19 community level is determined by the higher of the new admissions and inpatient beds metrics, based on the current level of new cases per 100,000 population in the past 7 days

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Data from: CDC Data Tracker Portal

# District Trajectories with Community Levels

Community Level (Title Color)
- High
- High-Med
- Med-High
- Medium
- Med-Low
- Low-Med
- Low

Curve shows smoothed case rate (per 100K)
CDC's new Community Level aggregated to district level in label & chart box color
Case Rate curve colored by Trajectory

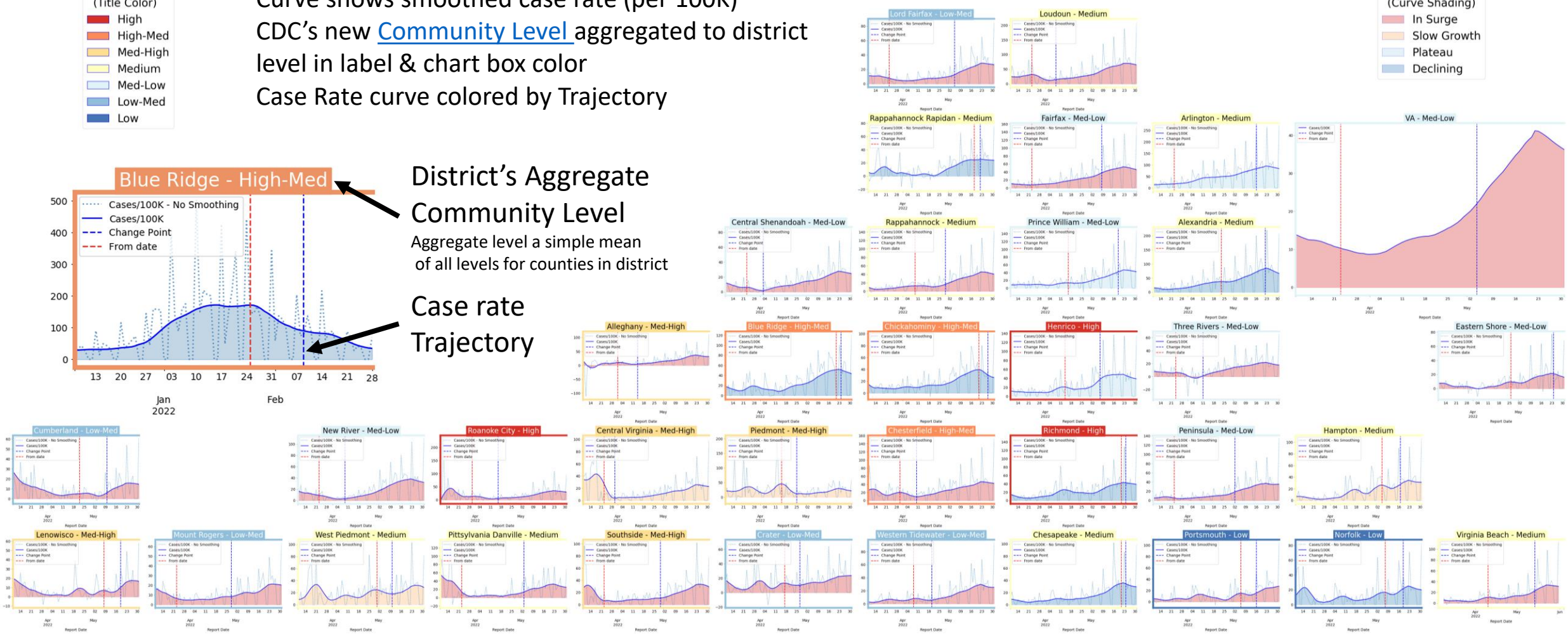
Trajectory (Curve Shading)
- In Surge
- Slow Growth
- Plateau
- Declining




District's Aggregate Community Level

Aggregate level a simple mean of all levels for counties in district

Case rate Trajectory

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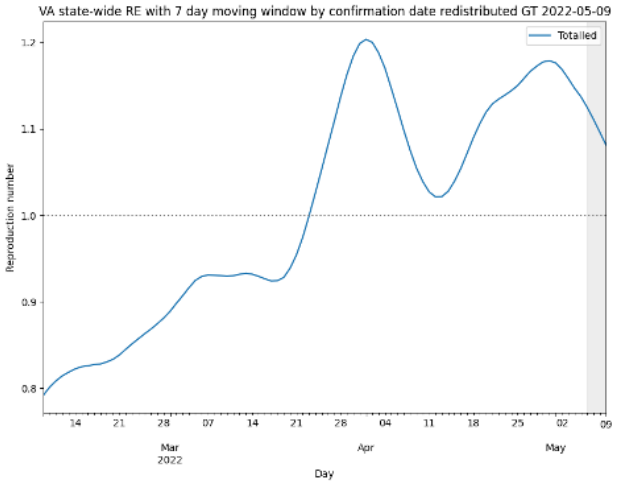
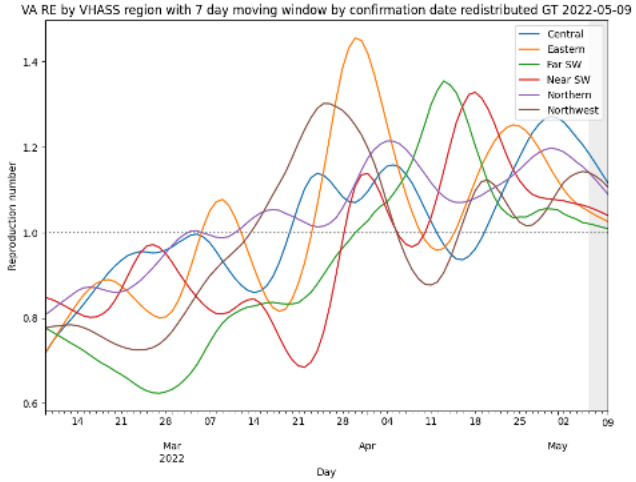
# Estimating Daily Reproductive Number – Redistributed gap

## May 31st Estimates

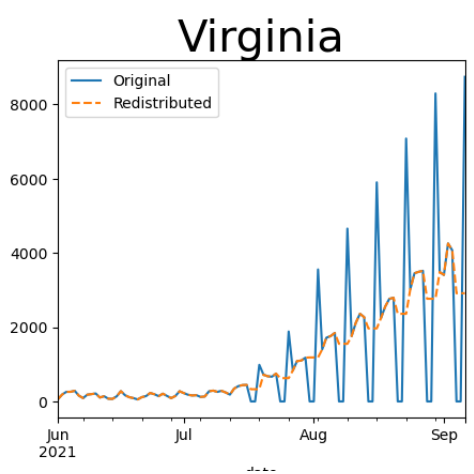
| Region | Date Confirmed $R_e$ | Date Confirmed Diff Last Week |
|---|---|---|
| State-wide | 0.877 | -0.145 |
| Central | 0.878 | -0.145 |
| Eastern | 0.930 | -0.094 |
| Far SW | 0.909 | -0.223 |
| Near SW | 0.857 | -0.203 |
| Northern | 0.877 | -0.141 |
| Northwest | 0.795 | -0.172 |




## Skipping Weekend Reports & holidays biases estimates

Redistributed "big" report day to fill in gaps, and then estimate R from "smoothed" time series




**Methodology**

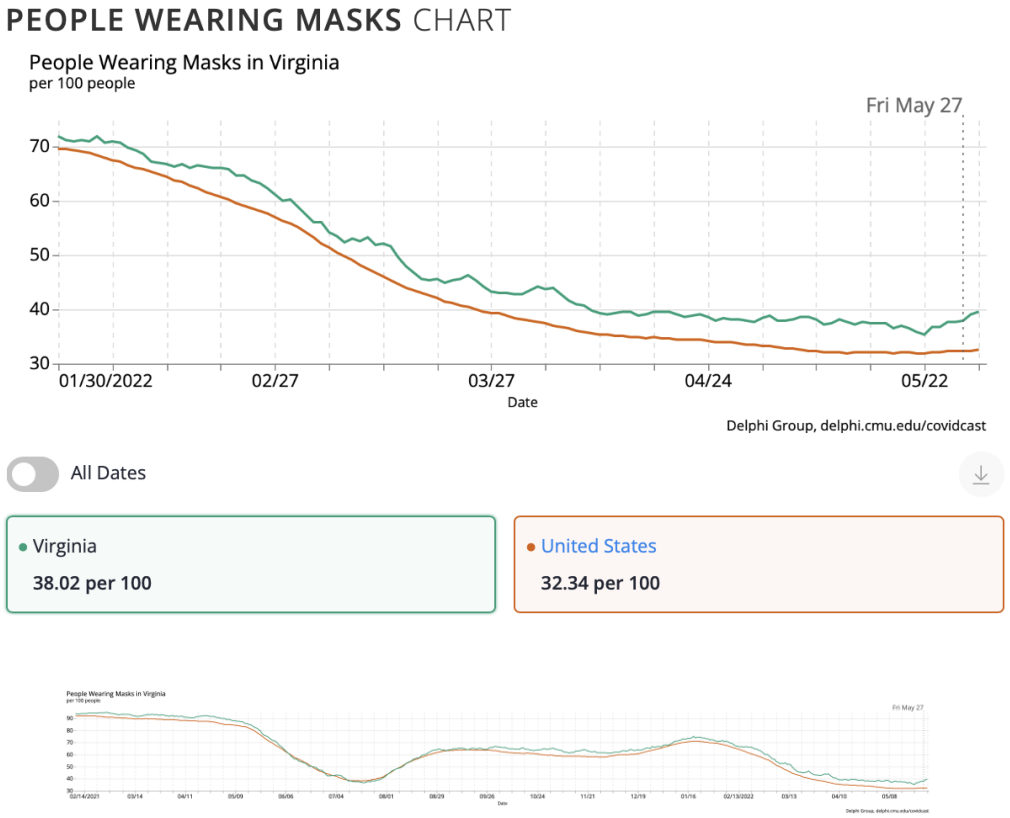
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: Discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

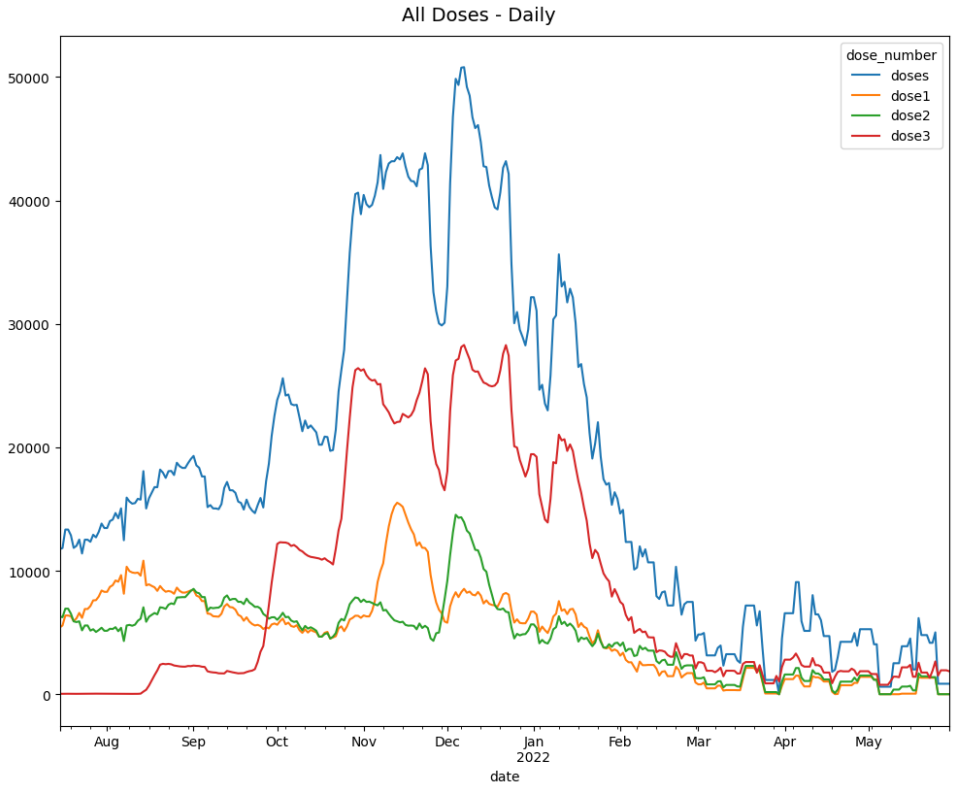

1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

# Mask Usage and Vaccination

**Self-reported mask usage continues to fall**

- VA rebounds slightly in mask wearing
- Mask wearing remains lower amongst unvaccinated, especially among least willing to be vaccinated



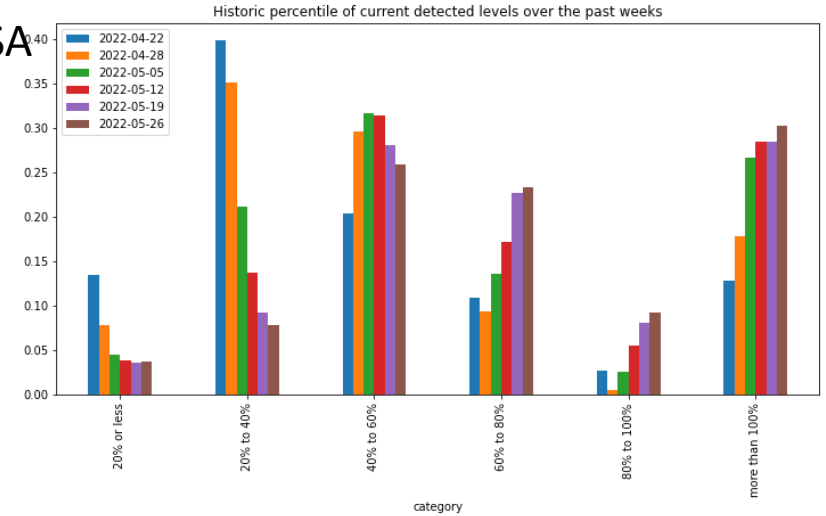

Data Source: https://covidcast.cmu.edu

# Wastewater Monitoring

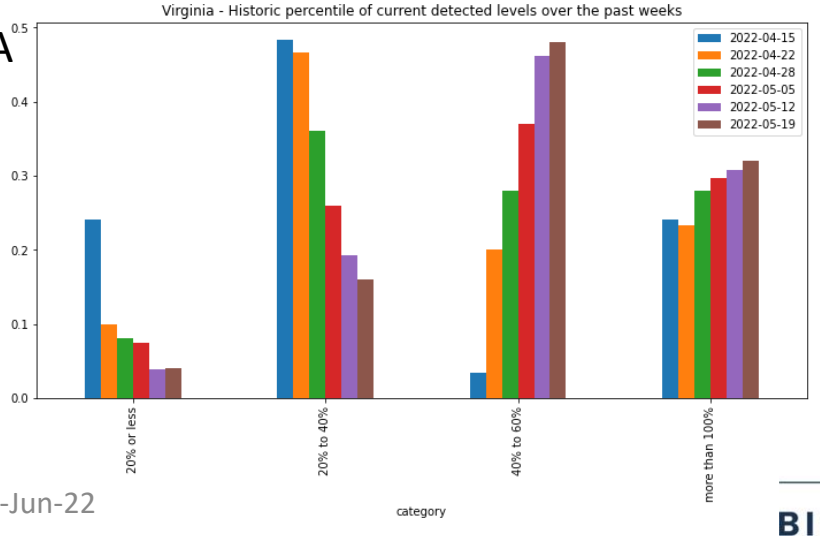
**Wastewater provides a coarse early warning of COVID-19 levels in communities**

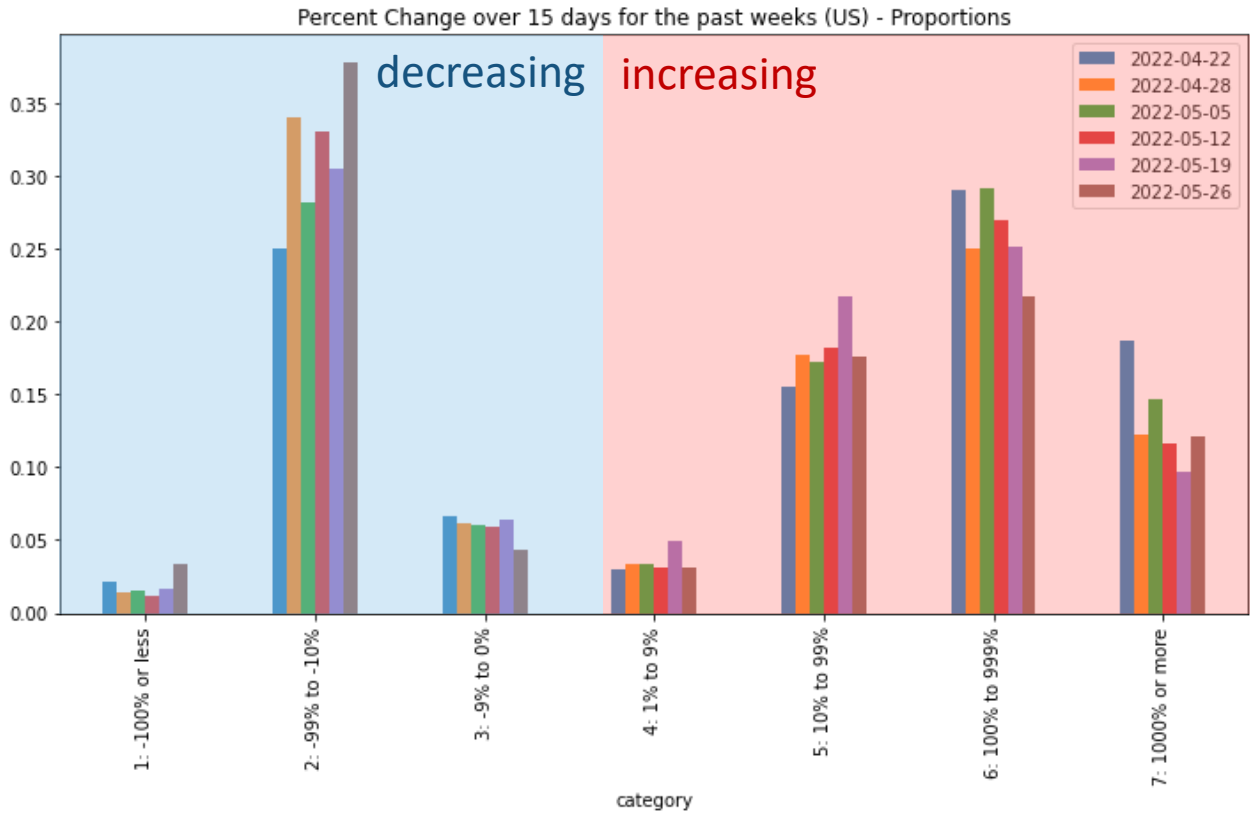
- Overall in the US, there is an increase in sites with increased levels of virus compared to 15 days ago
- Proportion of sites with current virus levels at or exceeding the max of previous historical levels, has further increased since last week

USA




VA

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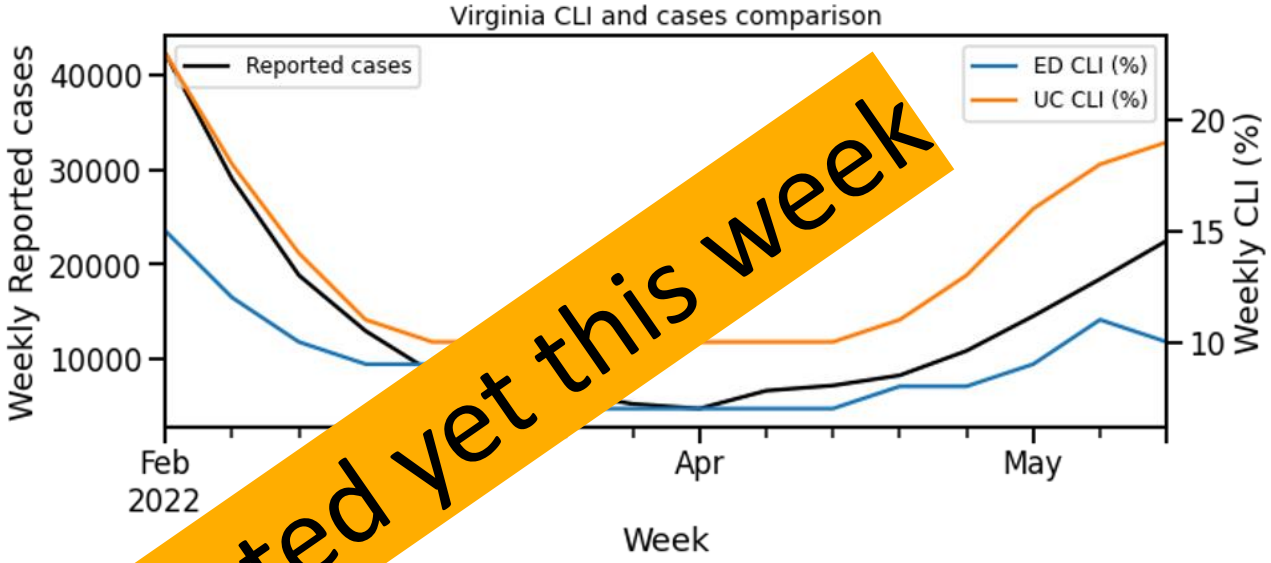
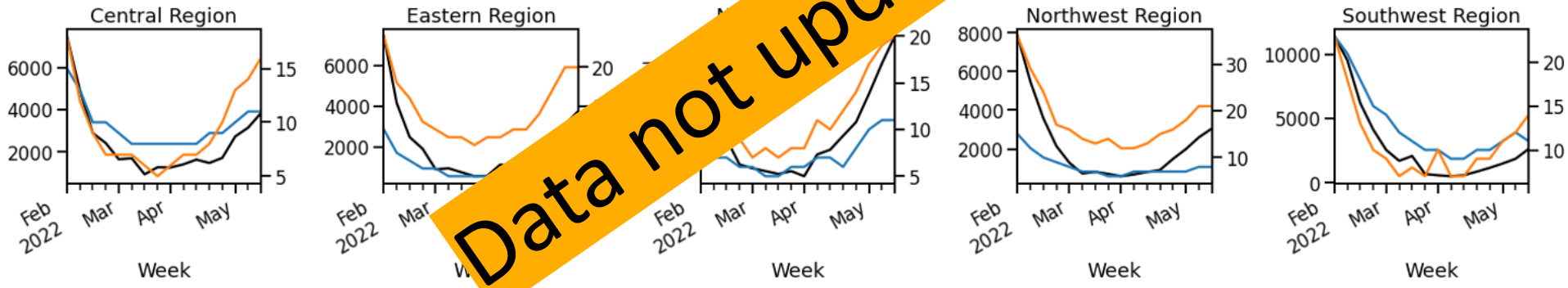
Data Source: [CDC Data Tracker]

# COVID-like Illness Activity

**COVID-like Illness (CLI) gives a measure of COVID transmission in the community**

- Emergency Dept (ED) based CLI is more correlated with case reporting
- Urgent Care (UC) is more sensitive and is a leading indicator but is prone to some false positives
- As testing behaviors and case ascertainment levels shift, these measures may capture disease better than confirmed cases
- Current trends in UC CLI are slightly up



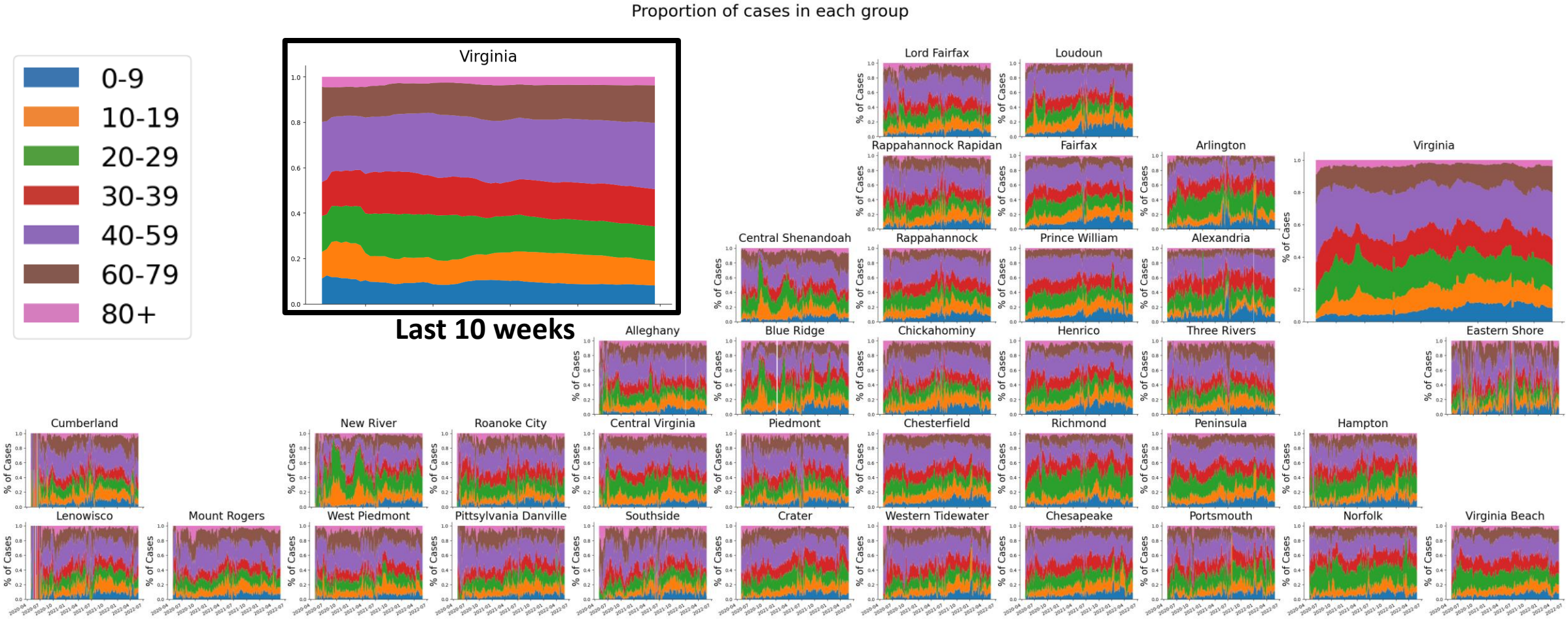




Data not updated yet this week

# Age-specific case rates across Virginia

**Normalized case-rates across age groups**

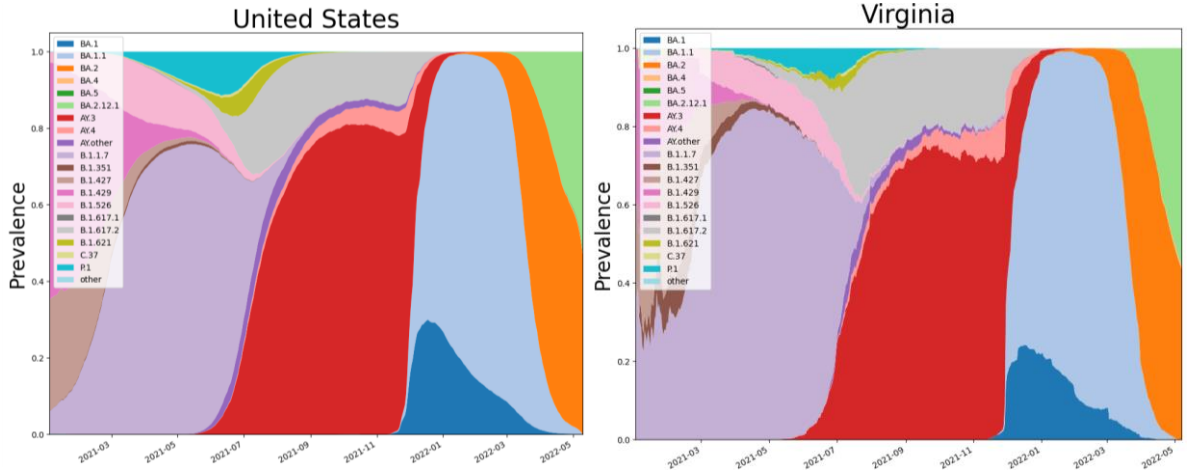
- Steady shift to older cases over the past couple months



# SARS-CoV2 Variants of Concern

**Emerging new variants will alter the future trajectories of pandemic and have implications for future control**

- Emerging variants can:
  - Increase transmissibility
  - Increase severity (more hospitalizations and/or deaths)
  - Limit immunity provided by prior infection and vaccinations
- Genomic surveillance remains very limited
  - Challenges ability to estimate impact in US to date and estimation of arrival and potential impact in future




| WHO label | Pango lineage* | GISAID clade | Nextstrain clade | Additional amino acid changes monitored* | Earliest documented samples | Date of designation |
|---|---|---|---|---|---|---|
| Alpha | B.1.1.7 | GRY | 20I (V1) | +S:484K<br>+S:452R | United Kingdom, Sep-2020 | 18-Dec-2020 |
| Beta | B.1.351 | GH/501Y.V2 | 20H (V2) | +S:L18F | South Africa, May-2020 | 18-Dec-2020 |
| Gamma | P.1 | GR/501Y.V3 | 20J (V3) | +S:681H | Brazil, Nov-2020 | 11-Jan-2021 |
| Delta | B.1.617.2 | G/478K.V1 | 21A, 21I, 21J | +S:417N<br>+S:484K | India, Oct-2020 | VOI: 4-Apr-2021<br>VOC: 11-May-2021 |
| Omicron* | B.1.1.529 | GRA | 21K, 21L | +R346K | Multiple countries, Nov-2021 | VUM: 24-Nov-2021<br>VOC: 26-Nov-2021 |

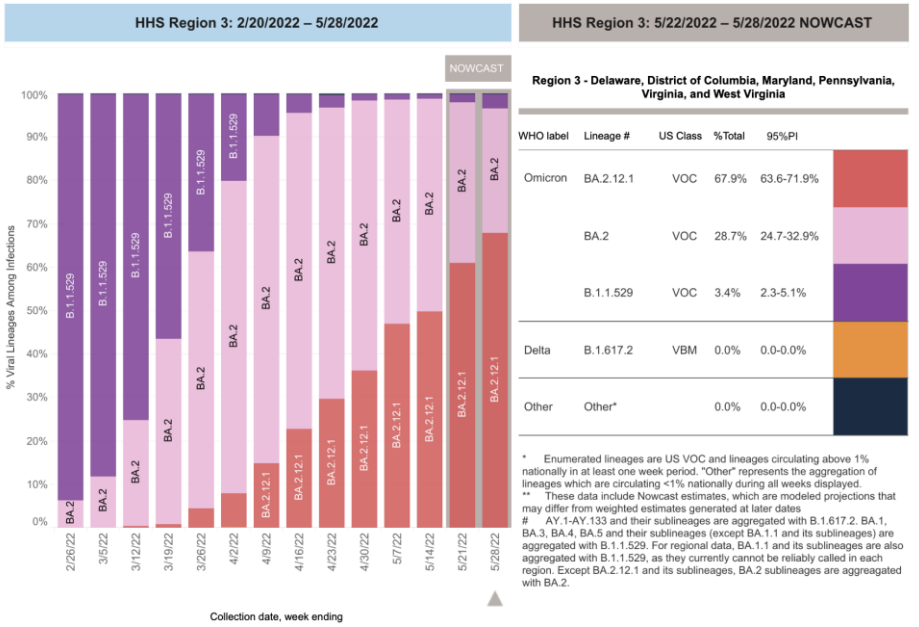
World Health Organization [WHO](#)

**Omicron Prevalences**

**subvariant BA.2 dominates**

**CDC nowcast for week ending May 28th in Region 3 with BA 2.12.1 at 68% (last week 66%), growth stalling**

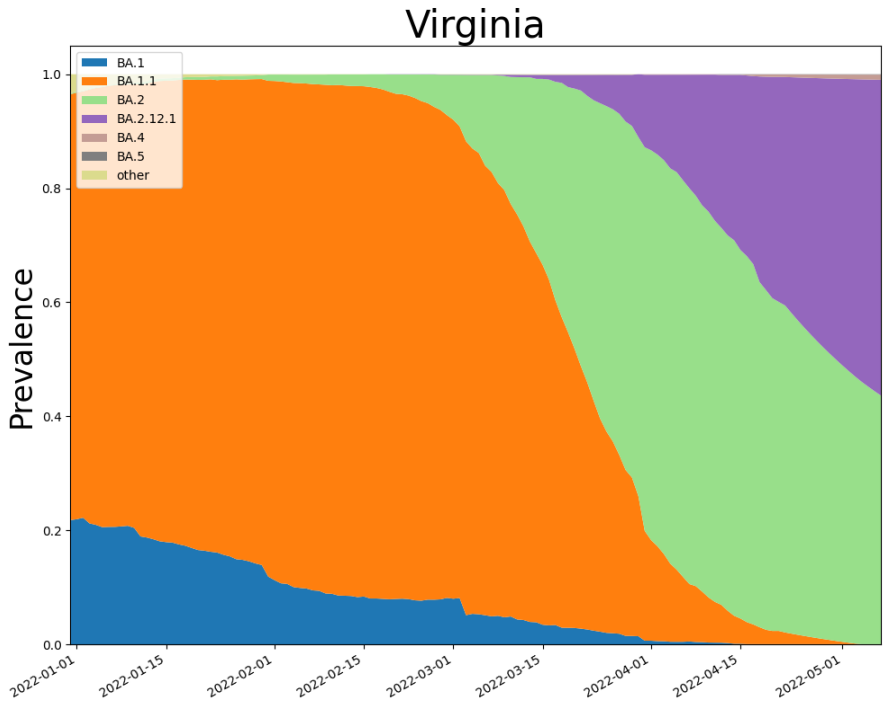
**Overall BA.2.12.1 in USA now at 59% (last week 52%), growth stalling**

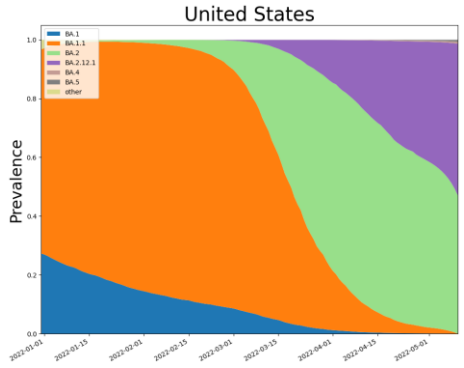



CDC [CDC Variant Tracking](#)

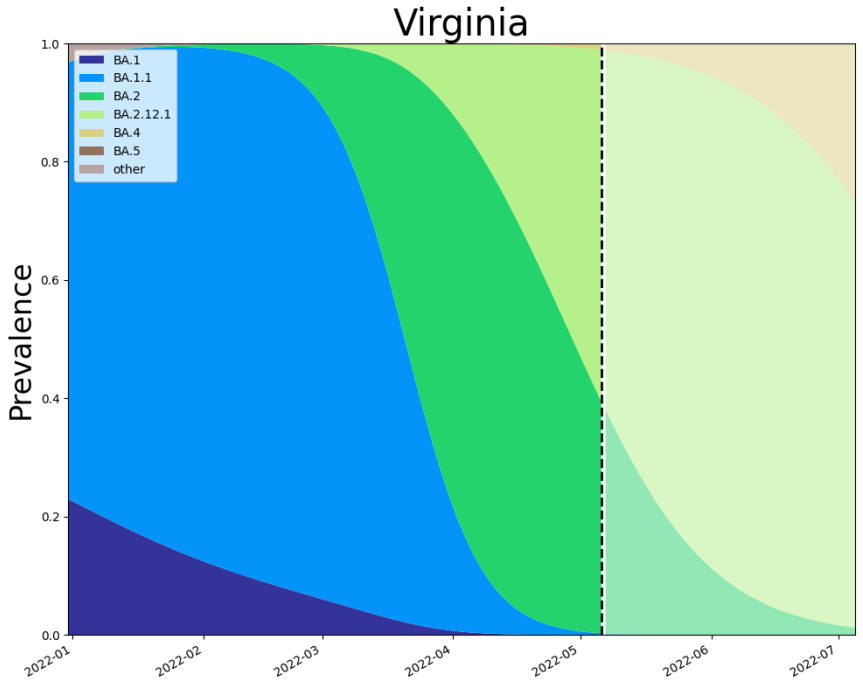
# SARS-CoV2 Omicron and Sub-Variants

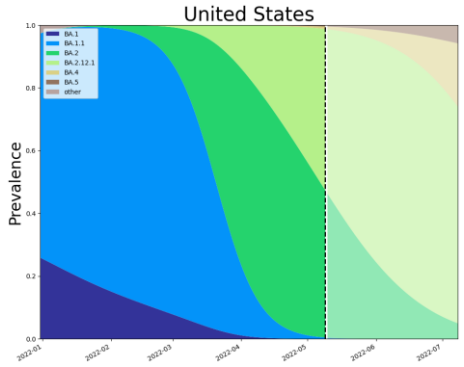
**As detected in whole Genomes in public repositories**




VoC Polynomial Fit Projections



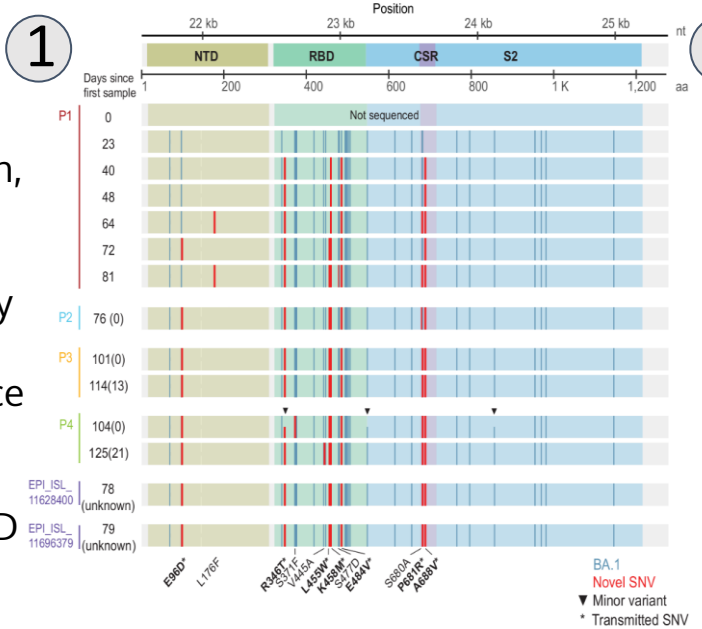

Note: Data lags force projections to start in past. Everything from dotted line forward is a projection.

GISAID outbreak.info

# Pandemic Pubs

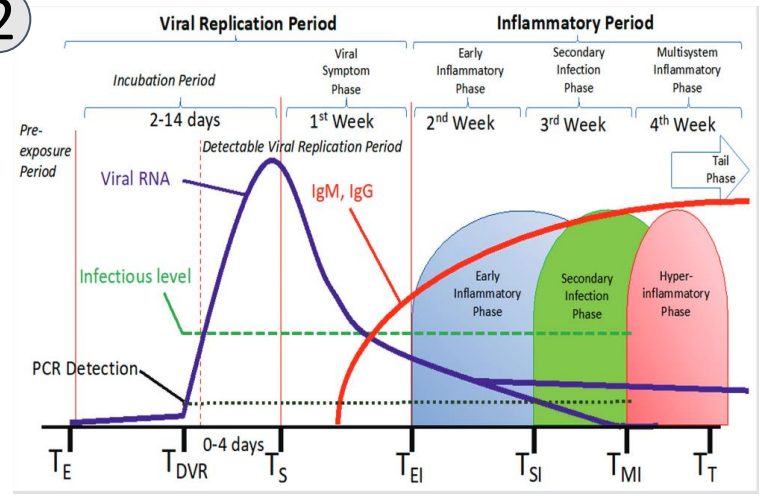
**1.** Mt. Sinai documents BA.1 immunocompromised infection, accumulation of eight AA substitutions over 12 weeks and likely onward transmission in the same health system.
**2.** Refresher: the stages of Covid-19 go well beyond a 5 day process.
**3.** Recent estimates of Rt using sequence surveillance place BA.4 and BA.5 as both having a transmission advantage over BA.2.12.1
**4.** Vaccines reduce but do not eliminate risk of Long COVID

1




The majority of amino acid changes occur at positions known to confer either immune escape or altered viral fusogenicity, some of the mutations have rarely been seen in other lineages, and represent a unique combination. Highlights need to limit spread and employ therapeutic strategies to limit duration of infection.
https://www.medrxiv.org/content/10.1101/2022.05.25.22275533v1

2

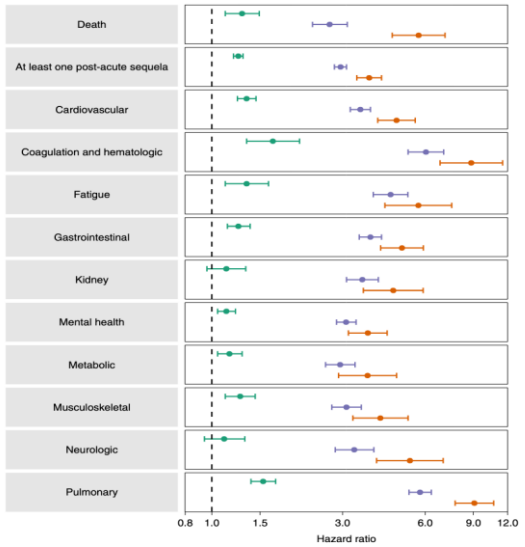



This 2021 article from researchers and medical professionals across the country highlights the phases of infection and the challenges posed by the timeline for exposure to infection. **One important note is that symptoms often present earlier than shown here.**
https://www.aidsreviews.com/get.php?x=aids_21_23_1_040-047.pdf&dp=0
https://twitter.com/danielgriffinmd/status/1531447216493174789

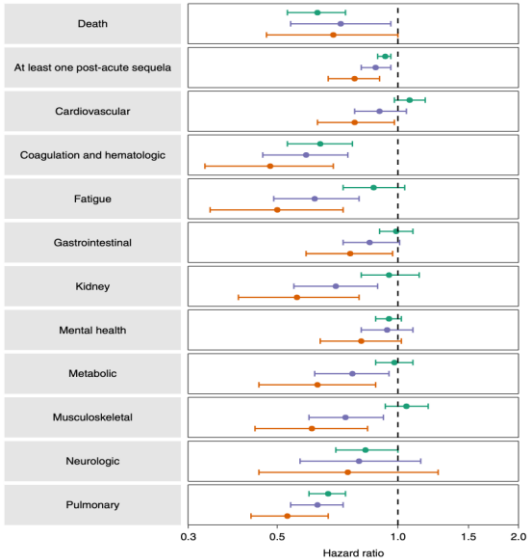
Researchers in St. Louis found that vaccines reduce Long COVID risk by 15% with the largest risk reduction in blood clots and pulmonary sequelae but less protection of other organ systems in Breakthrough Infections (BtI).
https://twitter.com/virusesimmunity/status/1529691455866155009?s=12&t=URVOvQl-fZSKAhfsNb9xMg
https://www.nature.com/articles/s41591-022-01840-0

4

**Risk and 6-month excess burden of post-acute sequelae in those with BtI by acute phase care setting.**

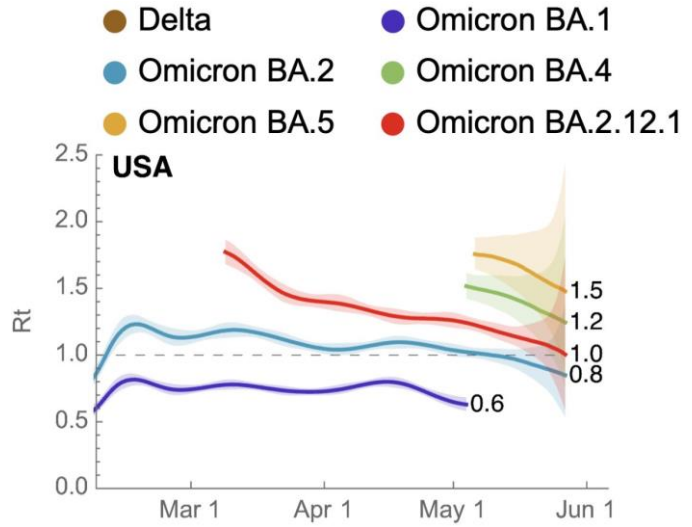



**Risk and 6-month excess burden of post-acute sequelae in those with BtI compared to those with SARS-CoV-2 infection without prior vaccination by acute phase care setting.**




33,940 individuals with BTI and several controls of people without evidence of SARS-CoV-2 infection, including contemporary (n = 4,983,491), historical (n = 5,785,273) and vaccinated (n = 2,566,369) controls.

3

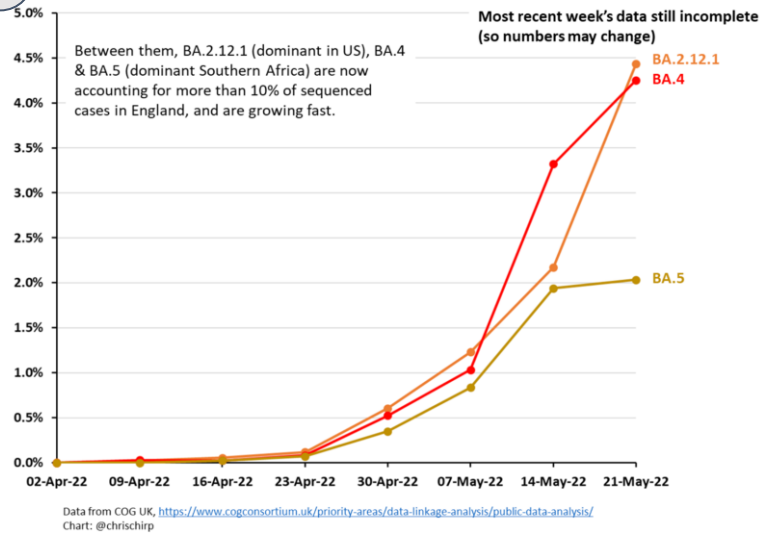



The transmission advantage, estimated from US surveillance, may stem from immune escape mutations that make it more resilient to neutralization provided by vaccination and prior infection.
https://twitter.com/trvrb/status/1530649638277029888

# Pandemic Pubs (last week)

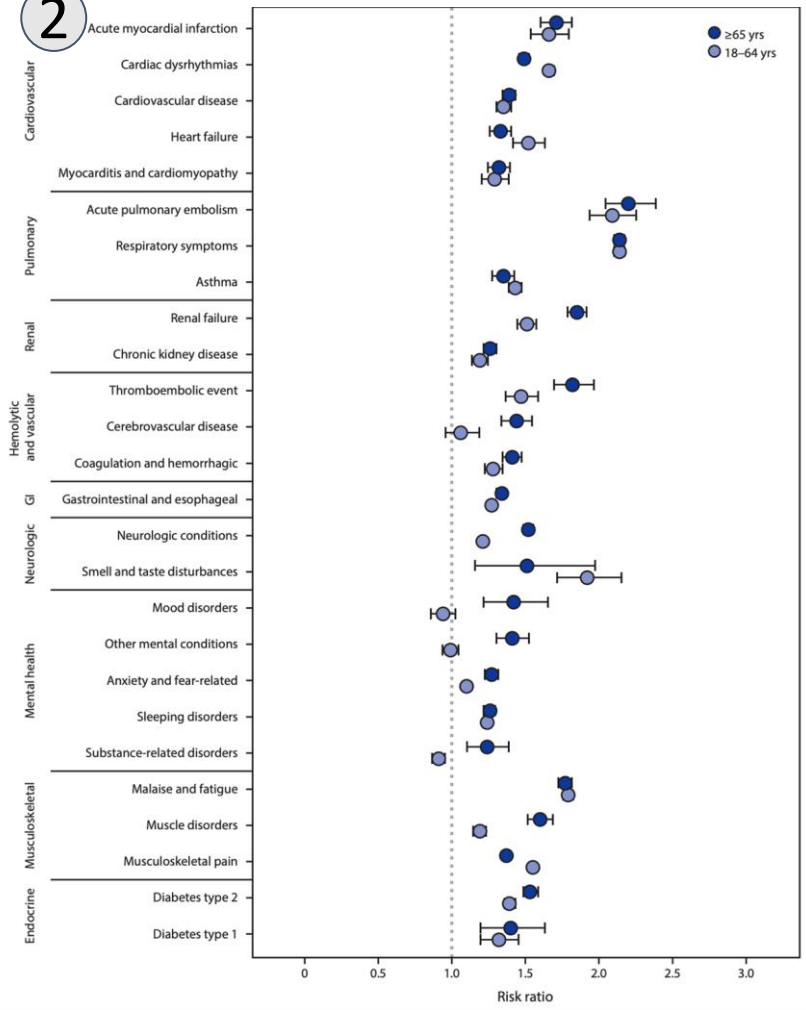
**1.** UK currently experiencing equal proportions BA.4 and BA.2.12.1. They are predicted to dominate circulating strains by early June.
**2.** COVID-19 survivors have twice the risk for developing pulmonary embolism or respiratory conditions
**3.** Quebec: 33.5% of individuals infected in the week ending May 12-17, 2022 had had COVID-19 previously. For 40% of these cases, the 1st infection occurred between December 2021 and February 2022.
**4.** Omicron BA.2 associated with reporting more symptoms, with greater disruption to daily activities, than BA.1

1



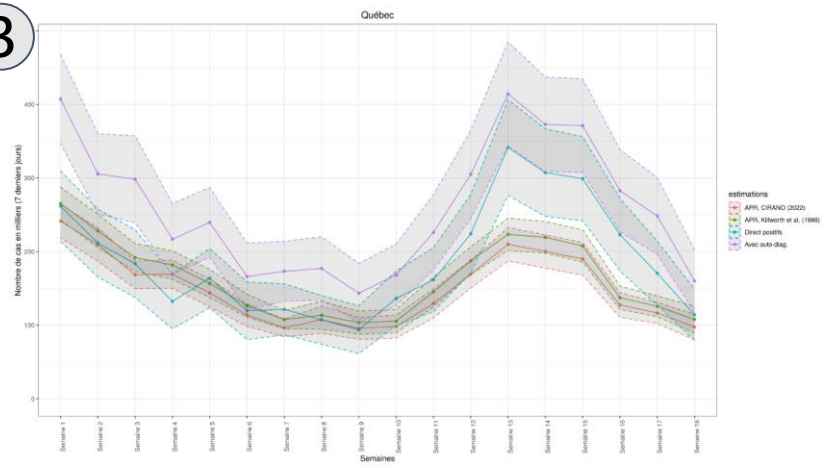

Within a background of decreasing cases, there is currently a VoC shift from BA.2 to other lineages of Omicron.
https://twitter.com/chrischirp/status/1528723315665272832

2




Researchers at the CDC conducted a retrospective matched cohort study to analyze EHRs during March 2020–November 2021, from Cerner Real-World Data,* a national, deidentified data set of approximately 63.4 million unique adult records from 110 data contributors in the 50 states, **found one in five COVID-19 survivors aged 18–64 years and one in four survivors aged ≥65 years experienced at least one incident condition that might be attributable to previous COVID-19.**
https://www.cdc.gov/mmwr/volumes/71/wr/mm7121e1.htm?s_cid=mm7121e1_w#contribAff

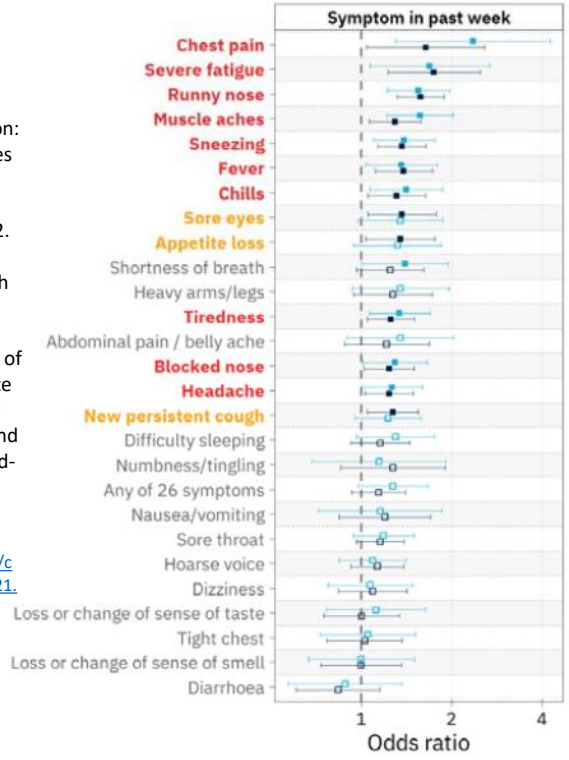
3




The CIRANO institute published a recent report estimating the incidence of COVID-19 cases in Quebec. As part of this report reinfection estimates resolve to between 4700 and 7700 reinfections a day, of which 1900 to 3000 a day had covid between Dec 21 and April 22.
https://twitter.com/lisa_iannattone/status/1527829419645095936?s=12&t=eMO1VOldWe5rS9HduhckYw
https://www.cirano.qc.ca/en/news/1081

4

BA.2 vs. BA.1



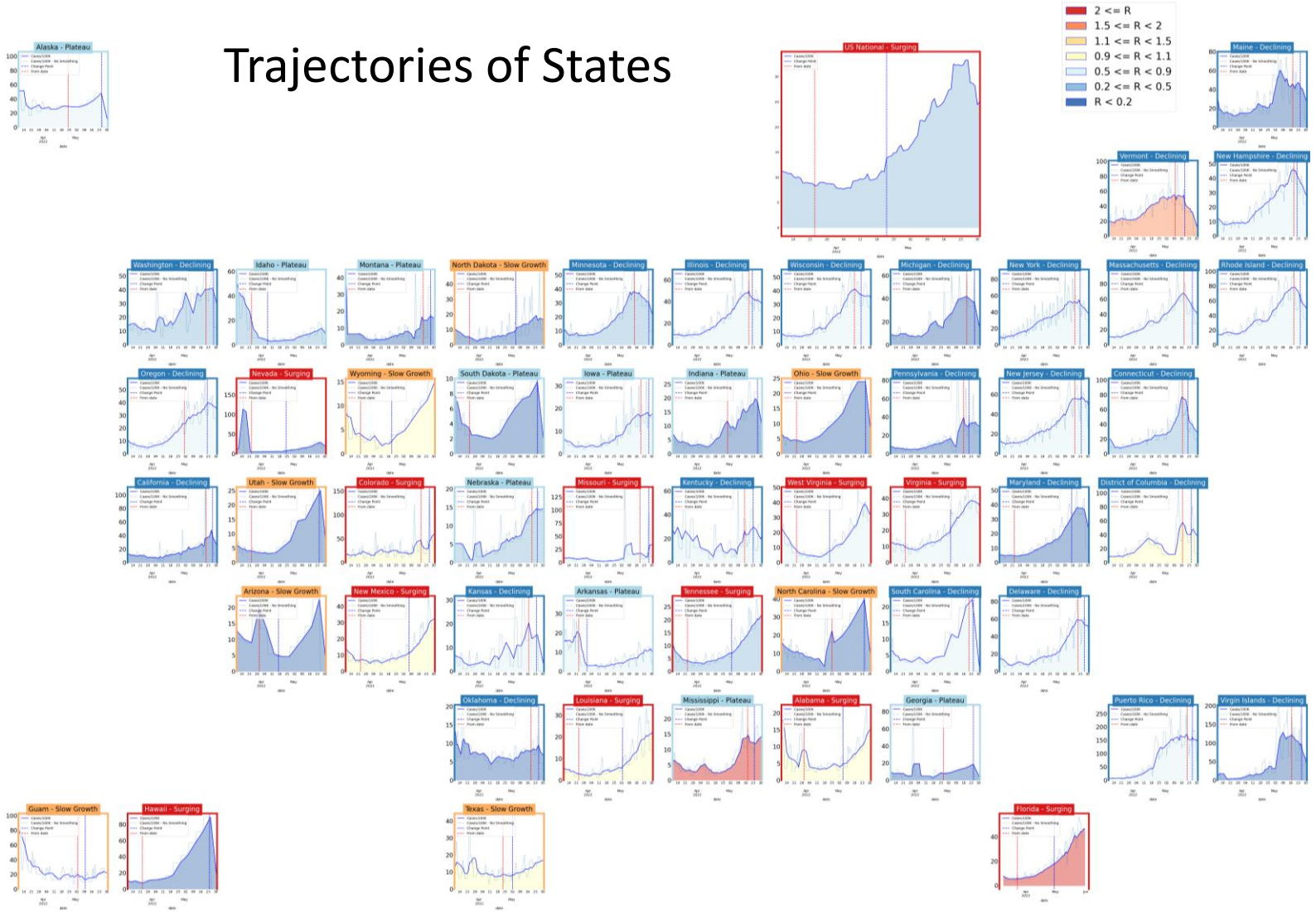

Imperial College London: among random samples of the population in England from 1 May 2020 to 31 March 2022. Changing symptom profiles associated with the different variants over that period, with lower reporting of loss of sense of smell and taste for Omicron compared to previous variants, and higher reporting of cold-like and influenza-like symptoms, controlling for vaccination status.
https://www.medrxiv.org/content/10.1101/2022.05.21.22275368v1

# United States Overall

- Nation pivoting towards more growth, focused in Northeast
- Most are sustained declines

| Status | # States |
|---|---|
| Declining | 25 (13) |
| Plateau | 10 (13) |
| Slow Growth | 8 (8) |
| In Surge | 11 (20) |

Trajectories of States

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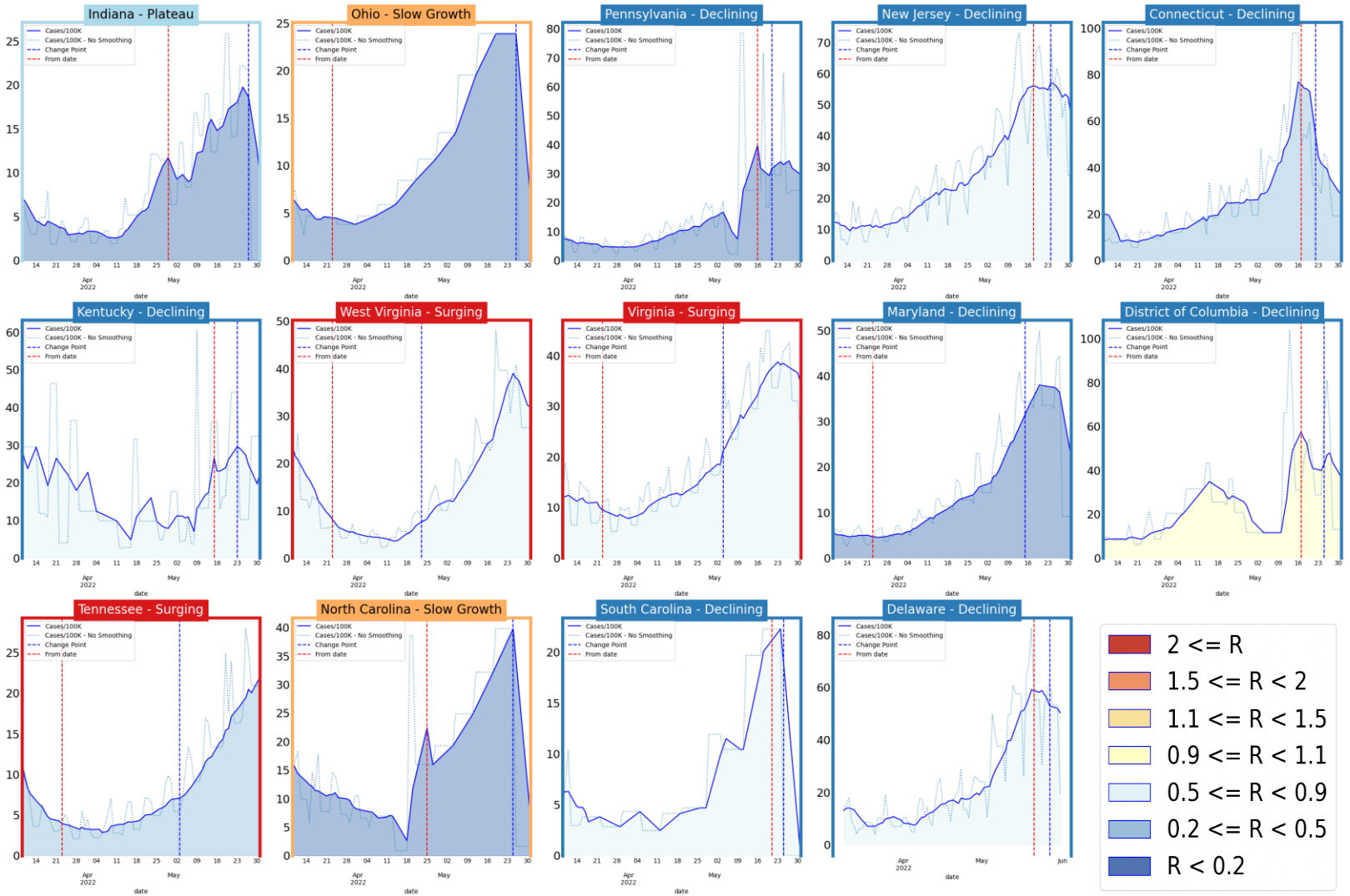
# Virginia and Her Neighbors

- More growth experienced across neighbors
- Some states at very high levels (CT, NJ)
- Neighbors to south starting to ramp up as well

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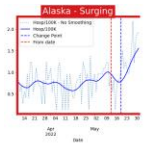
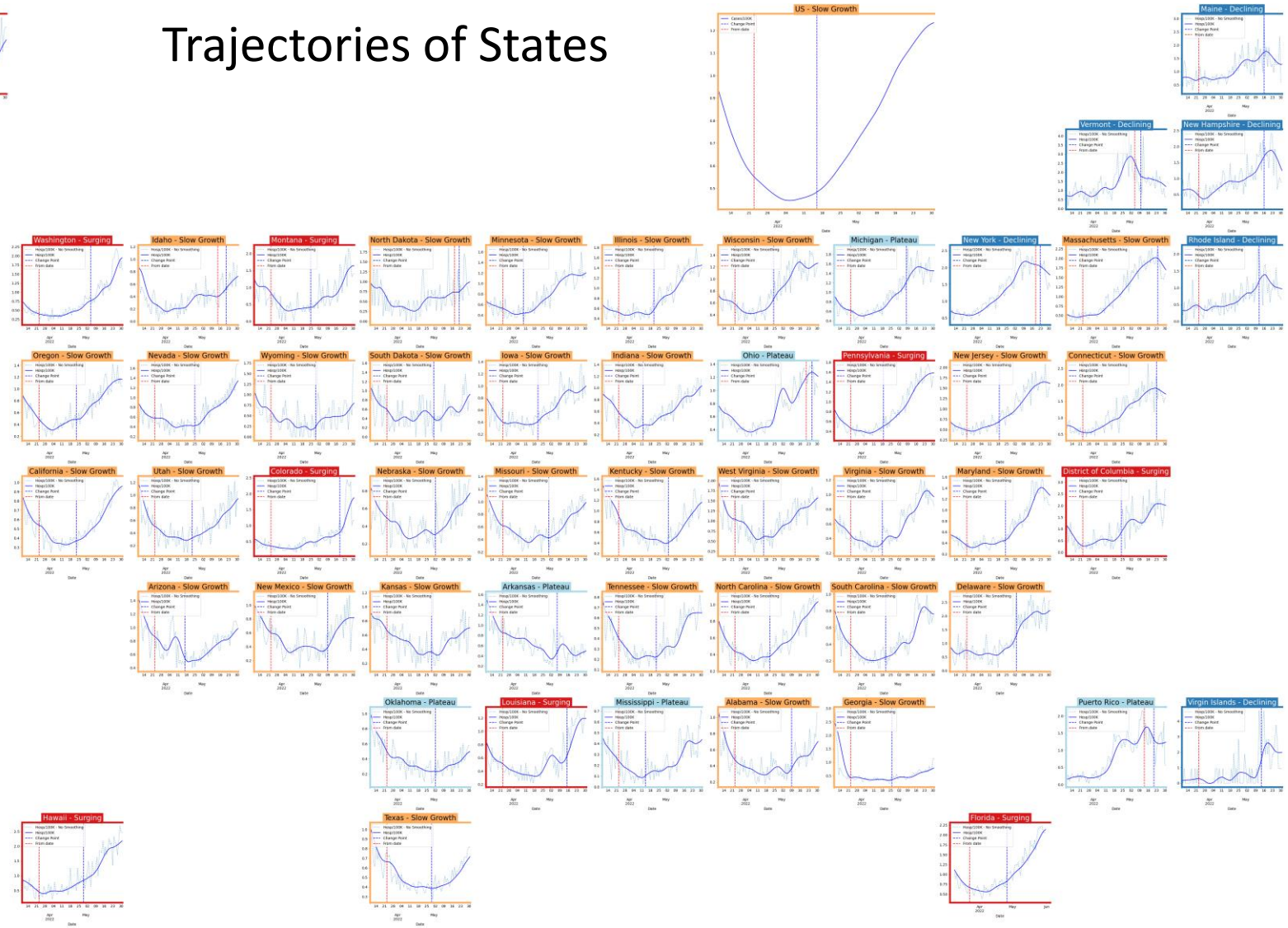
# United States Hospitalizations

- Hospital admissions are lagging case rates

| Status | # States (prev week) |
|---|---|
| Declining | 6 (3) |
| Plateau | 6 (8) |
| Slow Growth | 32 (30) |
| In Surge | 9 (12) |

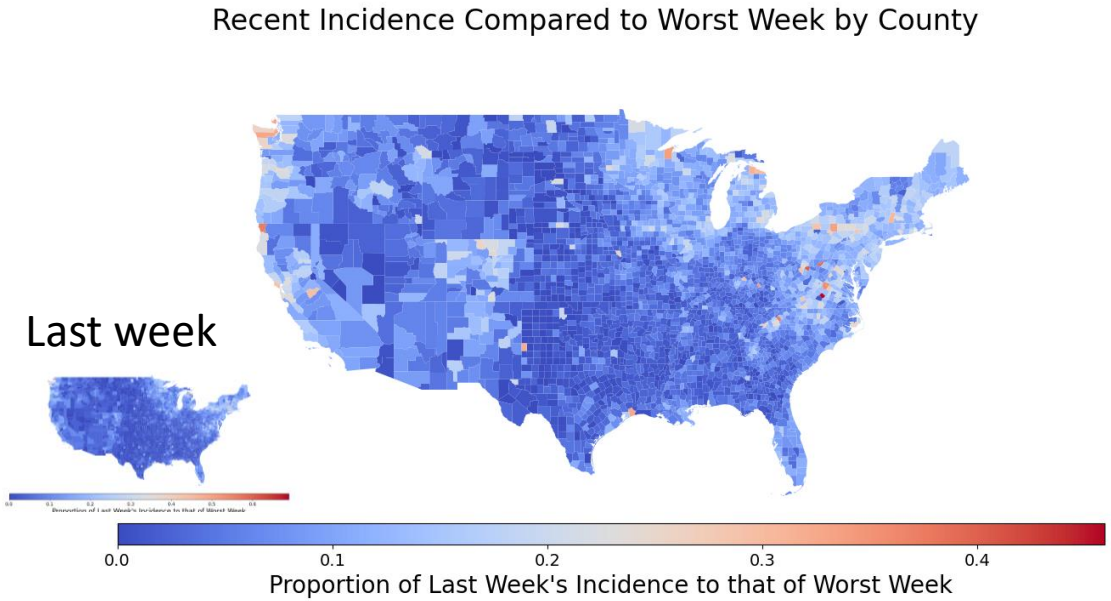


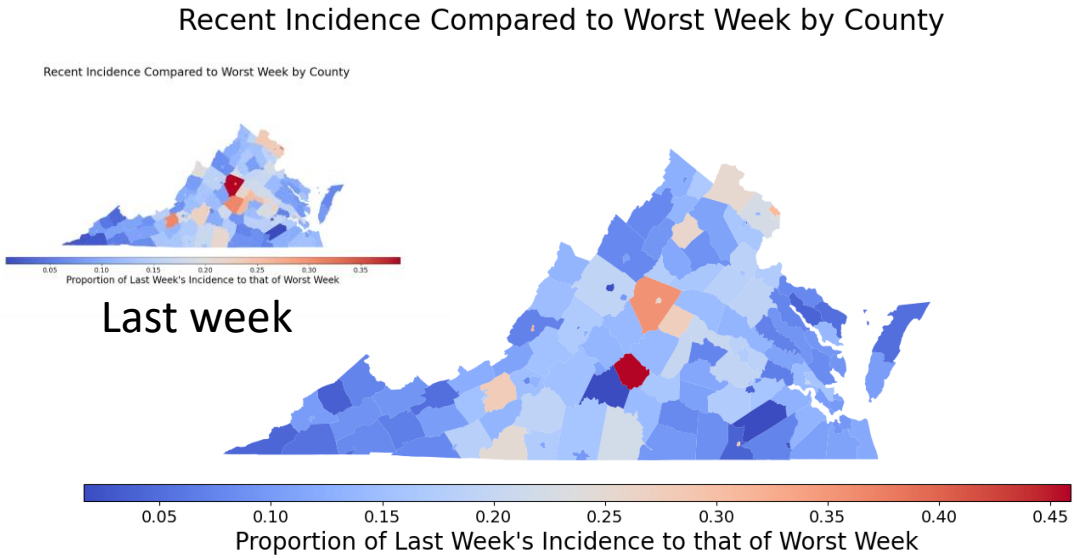

Trajectories of States



# County-level comparison to previous highest peak

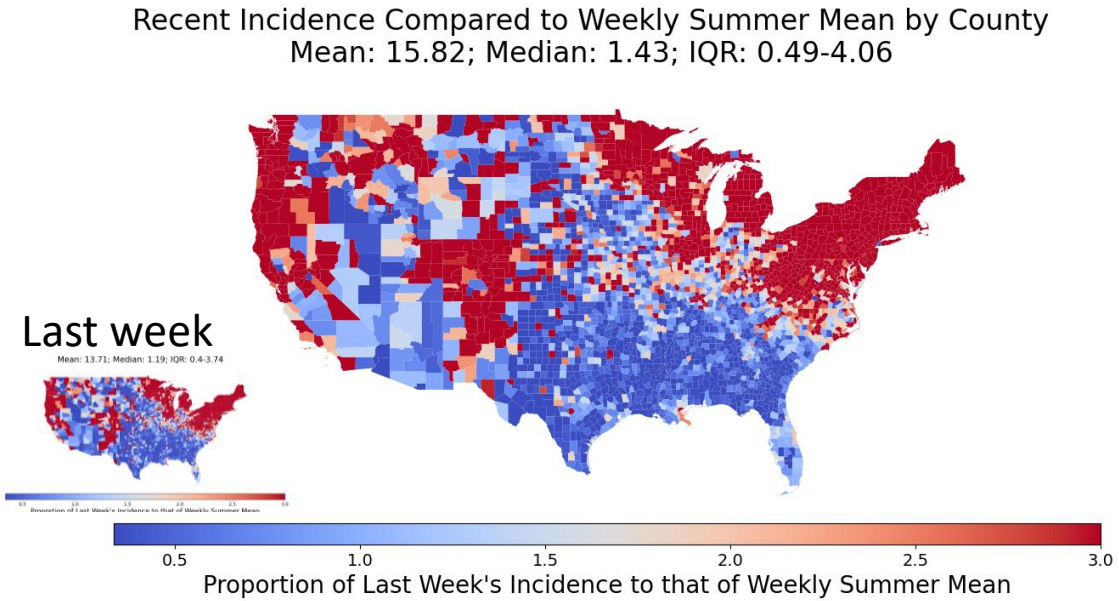
- Most counties in VA have had the highest case rate of the pandemic in the last week
- Nationally the number of counties at their highest rate has expanded considerably

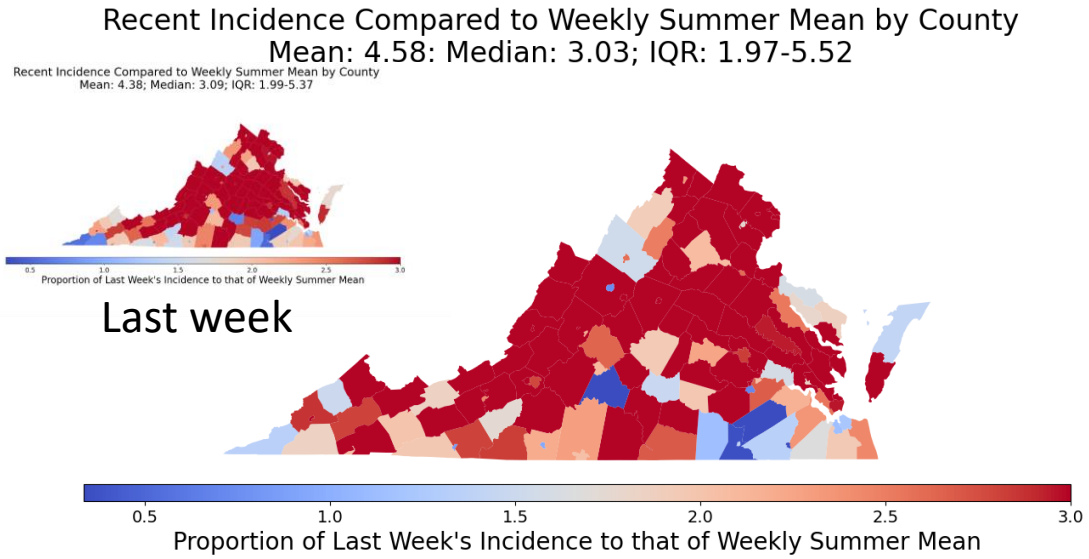


# County-level comparison to last Summer

- Most counties in VA have had the highest case rate of the pandemic in the last week
- Nationally the number of counties at their highest rate has expanded considerably



# Using Ensemble Model to Guide Projections

Ensemble methodology that combines the Adaptive with machine learning and statistical models such as:

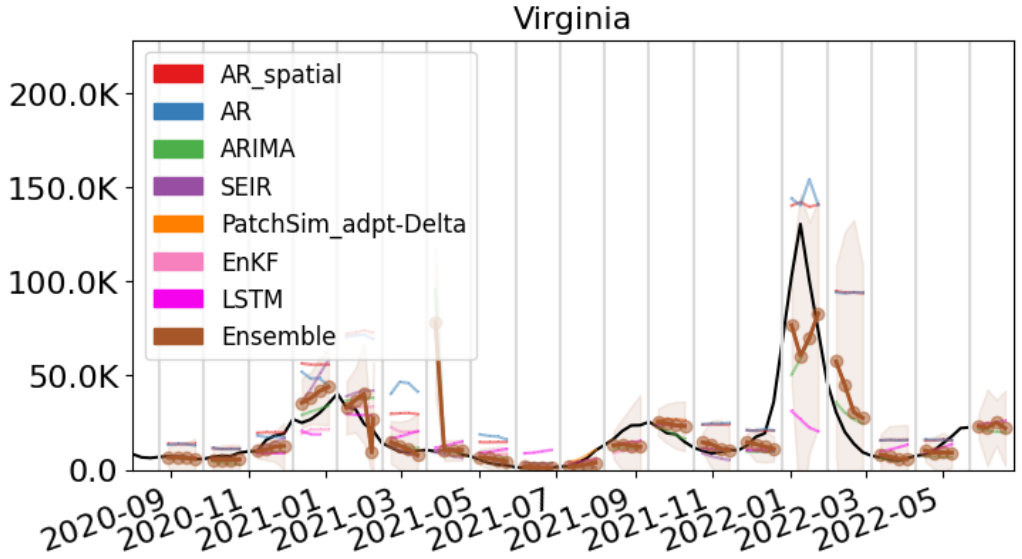
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

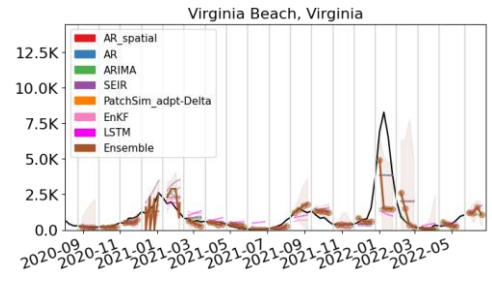
<u>Weekly forecasts</u> done at county level.

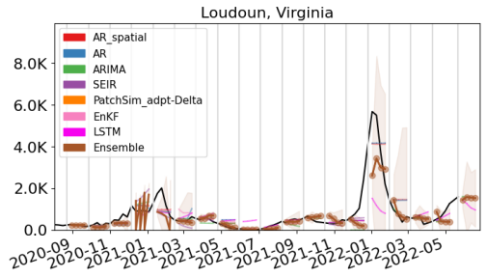
Models chosen because of their track record in disease forecasting and to increase diversity and robustness.

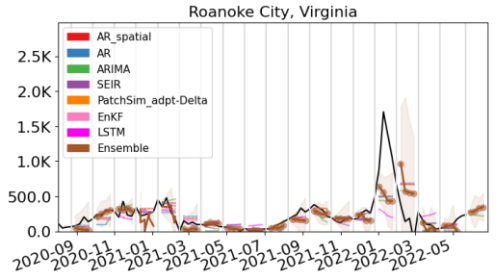
Ensemble forecast provides additional ‘surveillance’ for making scenario-based projections.

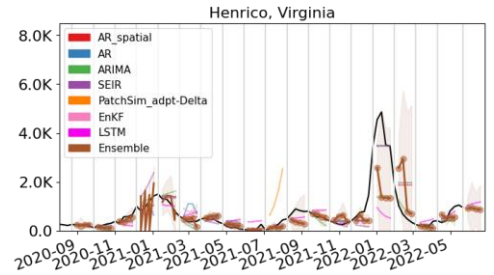
Also submitted to CDC Forecast Hub.



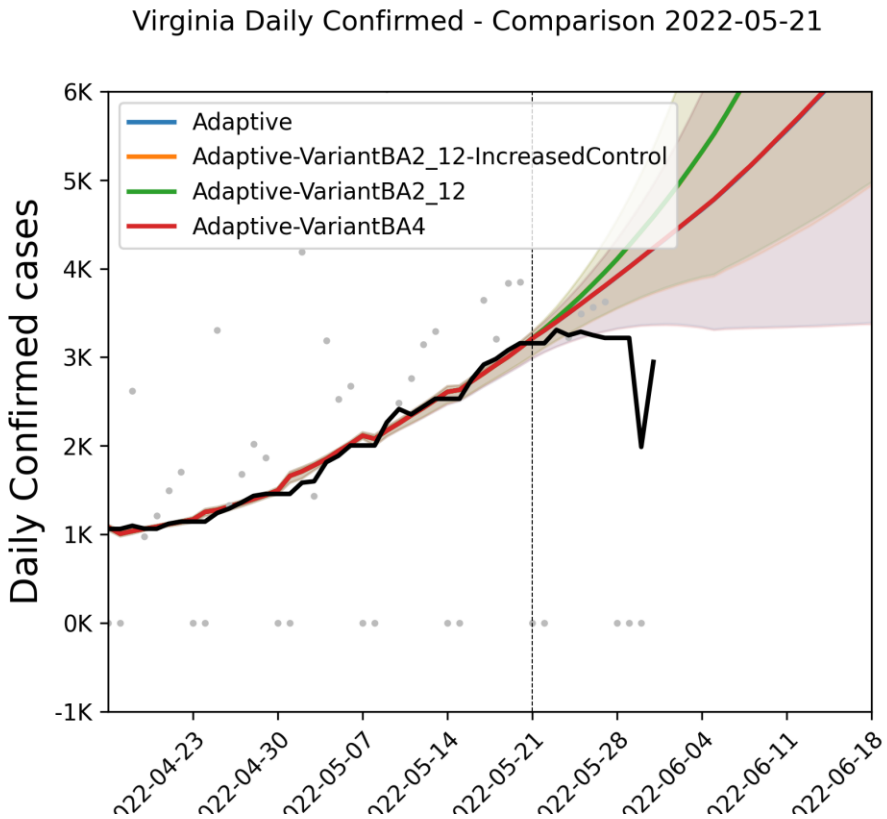



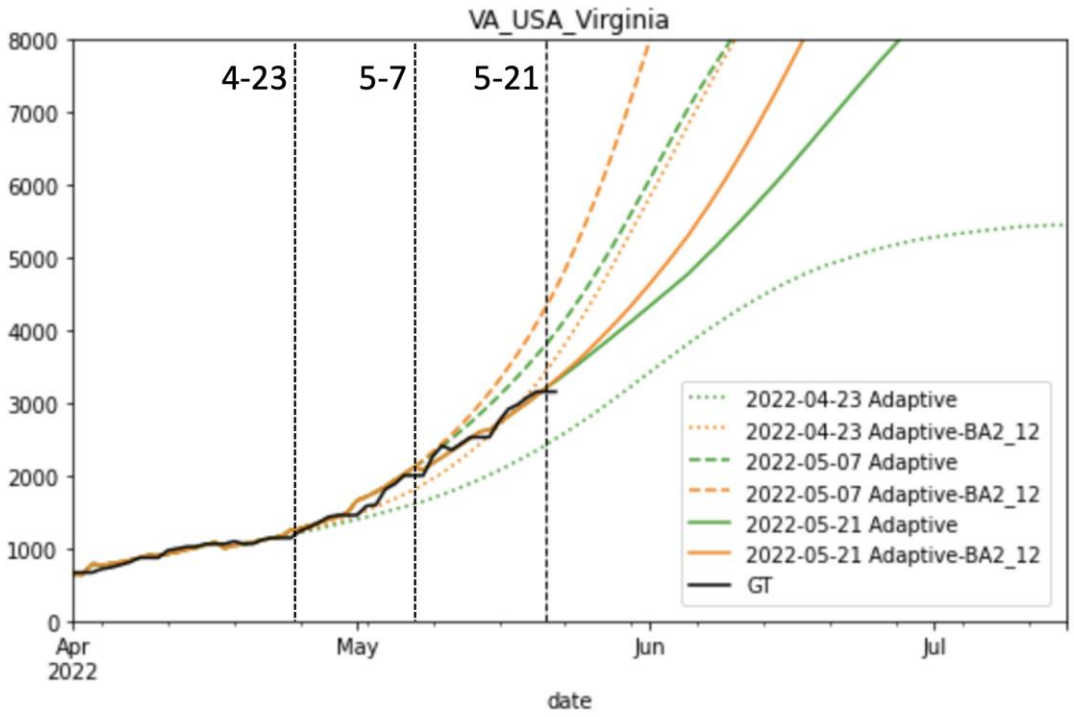



# Last week's projection comparison

**Projection from last week (May 21st )**




**Projections from previous month**



# Additional Analyses

# COVID-19 Scenario Modeling Hub – Round 13

Collaboration of multiple academic teams to provide national and state-by-state level projections for 4 aligned scenarios

- Round 13 results getting finalized
  - Scenarios:  New Variant in Summer and waning compared (yes/no new variant vs. 4 month or 10 month waning)
- Prelim results shared internally
- Only national consortium tracking Omicron wave well
- Rounds 4-12 now available

*Round 4 Results were published*

*May 5th, 2021 in MMWR*

https://covid19scenariomodelinghub.org/viz.html